

## Morphological and Thermal Properties of Polystyrene/Poly (Vinyl Chloride) Blends



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### ABSTRACT

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*PS/PVC blends, TGA, immiscible, polymer blends, morphology*

The present study investigated the morphological and thermal properties of polystyrene and polyvinyl chlorides blends (PS/PVC). The PS and PVC mixed by the solution casting by using cyclohexanone the ratios presented are 100/0, 80/20, 50/50, 20/80 and 0/100 according to the weight of PS/PVC. Where the mixture formation is confirmed by Fourier transform infrared (FT-IR), thermal gravimetric analysis (TGA), and differential scanning calorimetry (DSC) respectively. The spectral FT-IR results showed that the blend of PS/PVC did not have molecular reactions. The thermal gravimetry was used to achieve the thermal stability of the polymer blends. Two degrees of glass transition temperature were observed for each mixture. The results of DSC supported the absence of miscibility in the blend. The distribution of the phases in the virgin and blends was studied through scanning electron microscopy (SEM).

## 1. INTRODUCTION

Thermoplastic is widely used throughout the world in many different sectors due to its strong mechanical strength, durability, excellent process capability and durability [1]. This material usually called a plastic, has a good thermal and electrical insulation properties, and high chemical resistance [2]. Polystyrene (PS) and polyvinyl chloride (PVC) are the most widely used plastics [3]. PS possesses high modulus and high tensile strength, however, it is crisp and easy to crack [4]. PVC is one of the most versatile polymer with good flexibility, chemical resistance, film forming property, being economical and easy to modify, PVC has been extensively used in industrial application namely as packing material, cable insulation, and pipes [5, 6]. One of the most helpful technologies for material development with many different properties is polymer blending. These properties often appear is polymer blending which can be best in comparison to the properties of each one individual component polymer [7-9]. Blend systems have key features are simple and simple setup to change physical properties by compositional change [10, 11]. There is a great desire to study polymer matrices because of their importance in technical and academic aspects [12, 13].

In the present work, blends of PS/PVC were prepared in various weight ratios and to achieve the mixing through FTIR spectroscopy, scanning electron microscopy (SEM) and DSC studies. The thermal stability of these blends was verified by TGA study.

## 2. MATERIALS AND METHODS

### 2.1 Materials

The polymers used in this study was polystyrene (PS), having a molar mass of 104.15g/mol and solubility parameter 15.6-21.1MPa<sup>1/2</sup>, heat capacity (0.0473Kg/kmol at 100 k).

Polyvinyl chloride (PVC) (suspension) in the form of powder with a highly. Porous structure, K value (67-72), degree of polymerization 1250-1450. Cyclohexanone was used as a solvent.

### 2.2 Preparation of polystyrene/polyvinylchloride blend

Polystyrene/polyvinyl chlorid blends (PS/PVC) were prepared in various weight ratio 100/0, 80/20, 50/50, 20/80 and 0/100 wt%. A 3% (g/ml) solution of polymer mixture by dissolving polystyrene (PS) and polyvinyl chlorid (PVC) in cyclohexanone until a completely homogeneous solution is obtained. The solutions were mixed stirred for two hours at the temperature room. After poured in to the glass plates to evaporate cyclohexanone under ambient conditions.

### 2.3 Characterization

#### 2.3.1 Scanning electron microscopy (SEM)

The morphology of the composites study has been analyzed by Quanta FEG 250 SEM microscope operating at 5-10 kv.

The films have been coated with a gold thin layer a 10-200 µm to obtain good SEM micrographs.

### 2.3.2 Infrared spectroscopic analysis (FT-IR)

The FTIR analysis was performed to identify interactions between polymers in the blends. The spectra were collected on a JASCOFT/IR-4100 spectrophotometer at the wavelength range of 400–4000  $\text{cm}^{-1}$  with a resolution of 4  $\text{cm}^{-1}$ . We insert the film into the holder and use the clamp to ensure the best sample contact with the crystal. Minimum specimen size is approximately 5mm by 5mm by 0.1mm.

### 2.3.3 Thermal analysis

For this analysis, we used a thermal analysis calorimeter SDTQ 600 from the TA Instruments company which simultaneously performs the thermogravimetric Analysis (TGA) and differential scanning calorimetry (DSC). An initial mass sample (3-13 mg) was introduced into a platinum crucible under a nitrogen atmosphere of 50°C to 700°C, at a heating rate of 10°C/min.

## 3. RESULTS AND DISCUSSION

### 3.1 Scanning electron microscopy

The SEM micrographic of surface of polystyrene (PS) poly (vinyl chloride) (PVC) blend compositions (a) (80/20), (b) (50/50) and (c) (20/80) of (PS/PVC) shown in (Figure 1). The shape observed small spherical particles with smooth surface are of PVC in the matrix and are uniformly dispersed in the blend (Figure 1.a).

On the other hand, a large globular particle indicated by an arrow in the SEM images indicates the distribution of PS in the matrix PVC (Figure 1.c). The shape of the particles which is initially spherical, changes as the PVC spherical particles tend to join each other (Figure 1.c) thus leading ultimately to phase separation at 80 wt% PVC loading in PS. Whereas at low concentration there is a uniform distribution of phase-separated regions, the micro voids surrounding PVC in the PS-rich or PS in the PVC-rich phase droplets indicate weak interfacial adhesion in the blend.

### 3.2 FT-IR spectroscopic analysis

The spectral analysis FT-IR is used to detect and identify the presence of intermolecular interactions between the different constituent of the polymer mixtures [14, 15].

Figure 2 shows the FT-IR absorption spectra in the range of 400-4000  $\text{cm}^{-1}$  of PS/PVC blend of different ratio. For pure PVC, the observed vibrational bands at 2974  $\text{cm}^{-1}$  and 2912.9

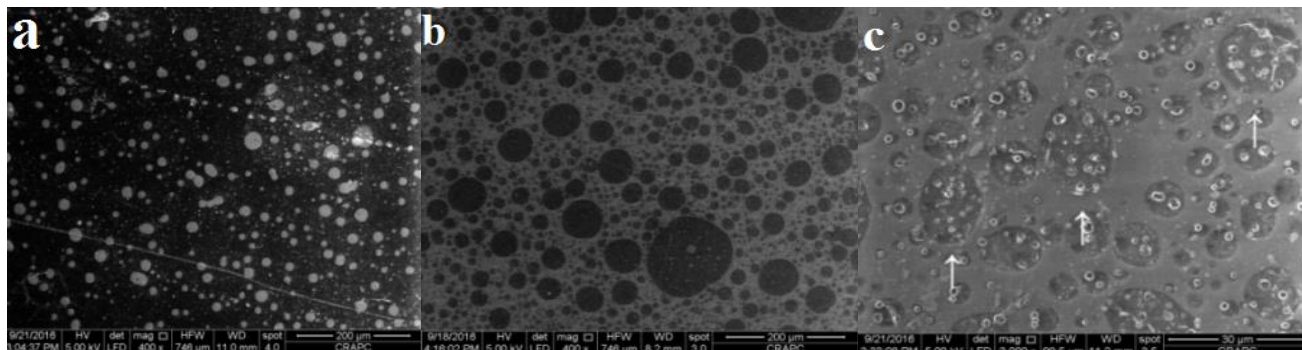
$\text{cm}^{-1}$  are ascribed to (C-H of CHCl), (C-H of CH<sub>2</sub>) respectively. Also the peak at 638  $\text{cm}^{-1}$  is ascribed to (C-Cl) bending vibrations. The frequency zone 600-700  $\text{cm}^{-1}$  which is attributed to C-Cl stretching vibration in PVC molecule can be used to identify the existence of specific interactions in PS/PVC blend [16].

The comparison between the PVC spectra and the other blends the spectrum showed that the PVC frequency zone does not change in the addition of PS in the system. On the other hand, the pure PS spectrum shows signals arising from aromatic bonds (see arrow in Figure 2). The range of 2900-3200  $\text{cm}^{-1}$  corresponds to aromatic C-H stretching vibration. The 1700 and 1500  $\text{cm}^{-1}$  signals are assigned to aromatic C=C in plane deformation vibration bending mode of the aromatic ring is shown at 756 and 590  $\text{cm}^{-1}$ . Comparison of the spectra showed which PS frequency region is not displaced with the addition of PVC to the mixture. This result indicates negligible intermolecular interactions between the components of the PS/PVC blends and the miscibility of the polymer couple is limited for the studied compositions.

### 3.3 Thermal analysis

Figure 3 shows the TGA/DTG thermograms of the PVC/PS blends and the neat constituents. The pure PS records a stability ranging from 50°C to 380°C when the sample is thermally stable. In the temperature range of 380°C- 430°C, the sample undergoes a very significant weight loss which is estimated at 98%, it is attributed to its depolymerization from polystyrene with the obtaining of styrene monomer. Pure PVC shows negligible weight loss up to 230°C. In the temperature range of 230°C to 280°C, a moderate weight loss is detected, resulting from the decomposition of low molecular weight additives, followed by dehydrochlorination taking place in the temperature range of 280°C to 360°C (Table 1).

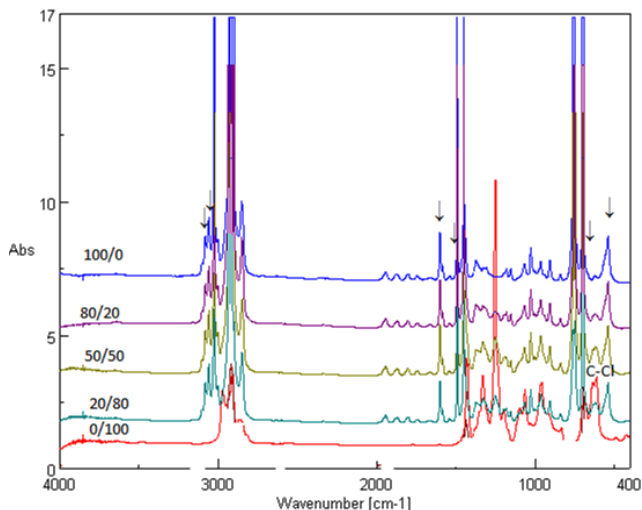
The weight loss curve for the PS/PVC blends (Figure 3, b, c, and d) is a superposition of the curves for the pure components. However, the heat flux curve indicates that decomposition of the PS phase occurs in the range of 429°C to 435°C, higher than the decomposition range of pure PS. This shift in the PS decomposition temperature range can be attributed to the stabilization of this phase by the migrated stabilization components. The weight loss of the PVC/PS blends in this temperature range (415°C-470°C) is equal to the PS content in the mixture with the weight loss of pure PVC in the same temperature range. This indicates that the decomposition of PVC and PS are simultaneous and independent processes.



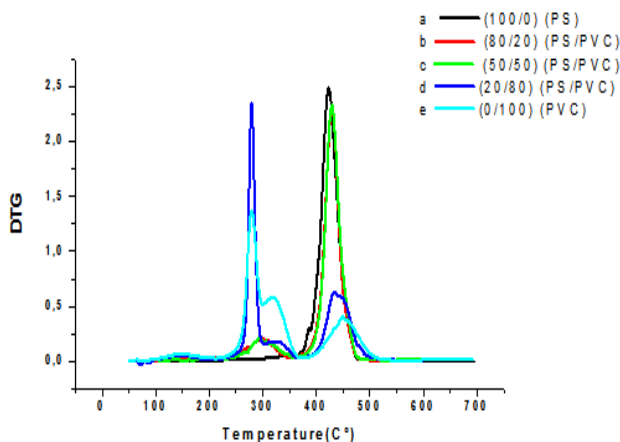
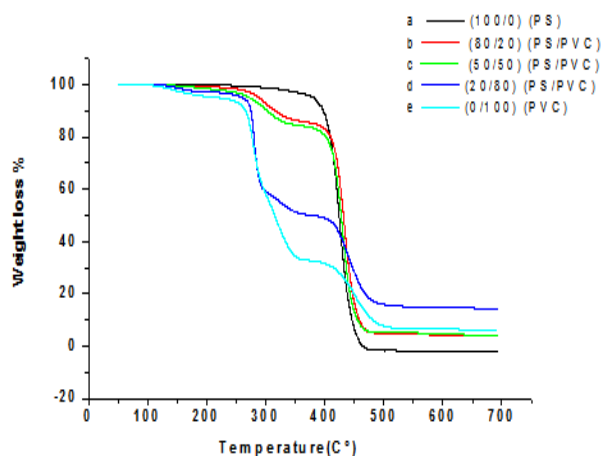
**Figure 1.** Scanning electron micrographs of PS/PVC blends (a) (80/20), (b) (50/50) and (c) (20/80)

**Table 1.** The decomposition temperature of PS/PVC samples with different blend ratios

Blend	PS	PS/PVC (80/20)	PS/PVC (50/50)	PS/PVC (20/80)	PVC	
Onset decomposition temperature (°C)	380	263.38	271.56	242.68	230	
First stage	T <sub>max</sub> (°C)	425.76	300.04	296.07	279.53	280.85
	V <sub>max</sub> (%/°C)	23.16	0.195	0.204	2.335	1.368
Second Stage	T <sub>max</sub> (°C)	/	429.74	430.40	435.03	449.59
	V <sub>max</sub> (%/°C)	/	2.290	2.330	0.625	0.399
Weight loss (%)	98	96.17	95.77	87.81	94.05	



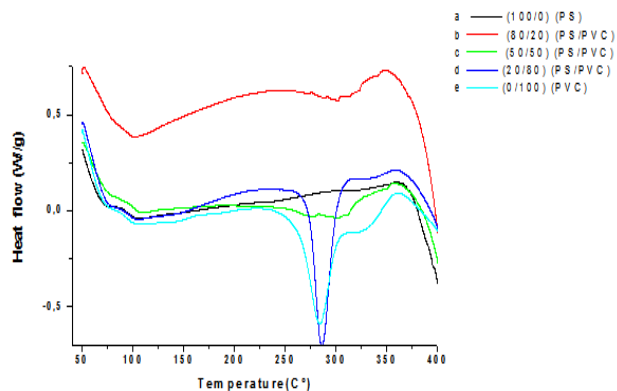
**Figure 2.** FT-IR spectra of PS, PVC and PS/PVC blends



**Figure 3.** Thermogravimetry (TG) and (DTG) of: (a) PS, (e) PVC and various PS/PVC blend compositions (b) (80/20), (c) (50/50) and (d) (20/80)

### 3.4 Differential scanning calorimetry analysis (DSC)

In order to determine the miscibility and thermal properties of the polymer blends, must measurement of the glass transition temperature (T<sub>g</sub>) [17]. For a fully miscible polymer blend, that must be obtained with a single glass transition temperature (T<sub>g</sub>). Whereas, for an immiscible polymer blend, each polymre must possess is town (T<sub>g</sub>) [18]. The curves of PS/PVC blends are showed in (Figure 4) the (PS) explicit glass transition at (100.23°C) while that of (PVC) was fined at (76.68°C). The PS/PVC blend shows two independent glass transitions, where clearly we find that each composition has a T<sub>g</sub> value of a pure Polymer PVC and PS. Judging from this result, we can say that the polymer pair of PS and PVC are immiscible.



**Figure 4.** Differential scanning calorimetry (DSC) of (a) (PS), (e) (PVC) and various (PS/PVC) blend compositions (b) (80/20), (c) (50/50) and (d) (20/80)

### 4. CONCLUSIONS

The polymer blend was prepared PS/PVC solvent casting technology where the characteristics of the blend were determined by SEM, FTIR, TGA, and DSC. The FTIR results of polymer blends indicates negligible intermolecular interaction between the constituents of PS/PVC blends. The immiscible of the polymer blends was confirmed by DSC due to two distinct glass transition temperature. The polymer blending improved the thermal stability of the blend at high temperatures as indicated by the high values of the Initial decomposition temperature (T<sub>d</sub>) of the determined by a thermogravimetry (TG) curves. A good morphology presented by the studied samples was observed by SEM.

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